extension of figure and structure; of something which has not motion or a combination of motions as force; of something which has not duration as persistence or duration with persistence and change.

In the mental world we have no knowledge of something which is not a judgment of consciousness and inference; of a judgment which is not a judgment of a body with number, extension, motion and duration. Every notion of something in the material world devoid of one or more of the constituents of matter is an illusion; every notion of something in the spiritual world devoid of the factors of matter and judgment is an illusion. These are the propositions to be explained and demonstrated.

In the following chapters an attempt will be made to show that we know much about matter, and although we do not know all, all we know is about matter in its categories of number, extension, motion, duration and judgment, or that we know of matter in its four categories and that we know of mind in the categories of judgment, but always this mind is associated with matter. In doing this we shall endeavor to discriminate between the certitudes and illusions current in human opinion.

In the intoxication of illusion facts seem cold and colorless, and the wrapt dreamer imagines that he dwells in a realm above science—in a world which as he thinks absorbs truth as the ocean the shower, and transforms it into a flood of philosophy. Feverish dreams are supposed to be glimpses of the unknown and unknowable, and the highest and dearest aspiration is to be absorbed in this sea of speculation. Nothing is worthy of contemplation but the mysterious. Yet the simple and the true remain. The history of science is the history of the discovery of the simple and the true; in its progress illusions are dispelled and certitudes remain.

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*NOTES ON THE DENSITY AND TEMPERATURE OF THE WATERS OF THE GULF OF MEXICO AND GULF STREAM.**

IT is estimated that the evaporation in the Gulf of Mexico amounts to about 60 inches a year, thus diminishing the amount of water in the Gulf 1.54 cubic miles per day. The evaporation is greatest in the central parts of the Gulf, following a line from east to west and approximately coinciding with the line of mean maximum of atmospheric pressure.

Precipitation, on the other hand, is greatest in the southwestern and northeastern parts of the Gulf, and least in the area intervening between the sandy plains of Yucatan and the arid regions of southern Texas and northern Mexico. By computation we find it to reach 32.7 inches annually, which is about 55 per centum of the evaporation, and it increases the waters of the Gulf by 0.84 cubic miles per day.

The water supply is further increased by river discharges, which amount to about 0.68 cubic miles per day; nearly 70 per centum of this volume being furnished by the Mississippi River. It will be seen that precipitation and river discharges feed the gulf by nearly the same amounts, but the effect produced by those feeders sinks into insignificance when compared with that produced by the inflowing current of the Yucatan Channel, which, according to a calculation from Lieut. Pillsbury's current observations, hurls the enormous quantity of 652 cubic miles of water per day into the Gulf, which quantity by itself would suffice to raise the level of the entire Gulf $5\frac{3}{4}$ feet within that space of time.

The Gulf stream carries off only about two-thirds of the water that is added to the volume of the Gulf in the manner indicated above, and evaporation being power-

* Abstract of a paper read to the Philosophical Society of Washington, by permission of the Superintendent of the U. S. Coast and Geodetic Survey.

less to remove the other third we are led to the conclusion that it flows back into the Caribbean as an undercurrent.

A study of the proportions of these currents has led to the conclusion that the Yucatan Channel current owes its existence mainly to the mechanical effect of the winds which produce an accumulation of waters in the northwestern part of the Caribbean Sea, but it is also, in part, due to differences in temperature and density between the waters of the latter and those of the Gulf. Hence, should the winds cease to influence the level of the Caribbean Sea, there would still be a surface current from this sea into the Gulf and an undercurrent in the opposite direction, similar to those which actually exist in the Strait of Gibraltar from and to the Atlantic Ocean.

The fresh water, which finds its way into the southwestern part of the Gulf, remains on the surface of the Gulf waters, but on account of its high temperature it readily assimilates with the sea water, and by continuous absorption of salt and heat from the lower strata reduces the latter to abnormally low temperatures.

The river and rainwater entering the northern parts of the Gulf also remains on the surface, but it preserves its distinctive character and low specific gravity for a much longer time period, owing to its comparatively low temperature, for not until it has reached the middle of the Gulf has it gathered salt and heat to its full capacity. Thus the course of the waters of the Mississippi River can be traced by their lightness for hundreds of miles into the Gulf of Mexico. Instead of flowing directly southeast towards the Strait of Florida, in accordance with the generally accepted supposition, these waters flow to the westward, which deflection undoubtedly is influenced by the existence of a lower water level in the western part of the Gulf, due to the piling up of the water in the eastern part by the flow from the Yucatan Channel. Notwithstanding the fact that the tendency of the Mississippi River waters, after entering the Gulf, is towards the west, and regardless of the strength of the inflowing Yucatan current, the predominent surface drift of the Gulf is towards the Strait of Florida, which phenomenon may be explained by assuming that the Yucatan current in its west and northward progress dips below the surface waters and continues as an undercurrent.

The surface waters of the central and eastern parts of the Gulf of Mexico, being propelled against the direction of the prevailing winds, are subjected to a powerful influence of evaporation, by which their specific gravity is increased to such an extent that their weight can no longer be borne on the surface, and sinking, they carry larger amounts of salt and heat into the deep strata than could reach such great depths in any other way. Thus only can we account for such temperatures as 60° and more at a depth of 250 fathoms, occurring off Cape San Antonio, half way between the Florida and Campeche Banks, against 44° in the western part of the Gulf and 47° in the Caribbean Sea at corresponding depths.

In conformity with the direct effects, known to result from decided differences of temperature at considerable depths in communicating parts of the ocean, there will be an undercurrent from the southeastern part of the Gulf toward the western part and another entering the Caribbean Sea, supporting the views expressed when considering the volume of water.

It is a remarkable phenomenon that the temperature in the substrata of those parts of the ocean adjacent to the Strait of Florida should be so nearly the same as that of the eastern part of the Gulf, thus precluding the existence of a subsurface counter-current in that strait; and a singu-

lar coincidence may be noted in the general character of the bed of that strait, it being only sufficiently deep to permit the passage of the Gulf Stream. It must not be supposed, however, that the under-current flowing into the Caribbean Sea entails a permanent saline and thermal loss upon the waters of the Gulf, as those abducted quantities of salt and heat, by a system of transfers, find their way into consecutively higher levels, and finally reach the surface current and return with it to the Gulf.

The current of the Yucatan Channel, notwithstanding its being the strongest current of the entire Gulf Stream system, possesses no great depth, and owing to its rapid spreading out it soon loses the best part of its velocity. The only exception in this respect is met with along the northern edge of Campeche Bank, where its flow shows considerable vitality, and it is here that it has evidently taken the shortest route to reach the western part of the Gulf.

It also appears to be very variable in its strength; when flowing at its best some of its waters are sent into the Strait of Florida, but its main strength is directed against the Gulf of Mexico with the effect of penning up its waters above the level of the Atlantic. Whenever the Yucatan current relaxes in activity, the waters of the Gulf of Mexico, in their reaction, frequently succeed in cutting it off altogether from reaching the Strait of Florida, and sometimes even in partly forcing it back at its eastern and weakest flank, into the Caribbean Sea.

The Gulf Stream, as has been shown by Lieutenant Pillsbury, is not the direct continuation of the Yucatan Channel current, but originates about in the middle of the western entrance to the Strait of Florida.

As it first appears in the Strait it is comparatively an insignificant current, and we are also disappointed in not finding it that fiery furnace which, according to its reputation, transmits sufficient heat to the eastern part of the Atlantic to modify the climate of the whole of western Europe. The fact appears to be that it does not start upon its journey at this point with more heat than it requires for its own use until it reaches Cape Florida, as it at once enters a contest against the cold waters descending from the Florida Bank, extending nearly halfway across the Strait. During its progress through the Strait these cold waters are forced back into the vicinity of the reefs, and by the time the Gulf Stream has reached Cape Florida it is in full possession of the Strait, from the surface to the bottom, and from the Bahama Banks to the Florida Reefs; its axis being but 15 miles distant from Cape Florida.

This victory, however, has been obtained at a great sacrifice of its supply of salt and heat, leaving it in an inadequate condition to engage unaided in another contest which it must immediately enter upon. Fortunately reinforcements are at hand, warm and highly saline waters, which have been slowly advancing along the Bahama Bank, join the Gulf stream at its point of weakness. Other and far more important succor gathered by the northeast trade winds, joins the Gulf stream on entering the ocean at the eastern end of the strait. Yet all these additions cannot account for the observed fact that the waters of the Gulf stream are so much warmer and more saline than those of the ocean, and in order to discover the source of this great heat we must look in a different direction than towards the Gulf of Mexico, or towards the surface drift of the Atlantic.

What has been described as taking place on the surface of the southeastern part of the Gulf is reënacted on a much larger scale on the entire surface of that part of the Atlantic Ocean lying between the Bermudas and the 'continental shelf,' off the Southern States. A powerful evaporation caused by the trade winds produces a con-

densation of the warm surface water, which sinks into greater depths and imparts a higher degree of temperature and salinity to the substrata than are met with in any other ocean. The waters of these substrata having a temperature from 60 to 64 degrees, at a depth of 250 fathoms, meet the cold waters, in a space about 40 miles wide, descending along the edge of the continental slope, which at the same depth (250 fathoms) have a temperature of only about 45 degrees.

Within this space of forty miles' width a transition of heat and salt is effected, resulting in an entire reconstruction of the superincumbent stratum of water, producing that peculiar distribution of salt and heat at the surface that is characteristic of the Gulf stream. When warm seawater comes into contact with colder seawater it becomes heavier, for the reason that the increase of density, due to loss of heat, surpasses the decrease, due to the loss of salt. When this occurs in the depths of the ocean the warm water will sink to still greater depths, but here (as also on the slopes of great submarine banks like the Bahama, Florida and Campeche Banks) this dense and warm water touches bottom, and another shift must be made to dispose of the excess of salt, the maintenance of equilibrium being a physical necessity.

The density of warm water is less affected by the addition of a certain quantity of salt than cold water would be, and for this reason the excess of salt and heat at the bottom, on the inner edge of the Gulf Stream, shifts to higher levels where, in consequence of higher temperatures, larger quantities of salt can be stowed away with less change of density than at greater depths. Thus, by a withdrawal of salt and heat from the greater depths and their accumulation at the surface, that peculiar distribution is attained which characterizes all the serial temperature observations of the Gulf Stream sections, including those obtained by the Challenger.

Observations show the highest specific gravities of the Gulf Stream waters to be in the latitudes of Capes Lookout and Hatteras, exceeding those of all other parts of the open ocean, and surpassed only by those of the Red Sea and of the western part of the Mediterranean.

Although the 'upheaval' of the waters of the Gulf Stream develops first in upward currents, in the substratum in which the transition of heat and salt begins, it is not improbable that these currents, like the winds in aërial circulation, may assume a more or less horizontal direction in their progress to the surface. It may also be assumed that the storage of heat in the surface stratum is not without influence upon the level of the Gulf Stream, and that this difference of level between the Gulf Stream and the adjacent areas of the ocean may call other currents into life, but a farther consideration of these subjects would lead us into the sphere of the so-called dynamics of the Gulf Stream, a field already ably discussed and sufficiently studied.

A. LINDENKOHL.

AN OPTICAL ILLUSION.

THE brilliant electric lights on the borders of the lake in the Baltimore park have served to call my attention to a phenomenon which is so very familiar that one is wholly disinclined to regard it as a 'phenomenon' at all. I refer to the fact that the long stream of light reflected by the surface of the water from a lamp on the opposite side does not look like an object lying upon the surface, but like a bright post projecting down into the water, in continuation of the lamp-post. This is without doubt a particular case of the illusion by which lines which have any position whatever in planes passing through the axis of the body (or, for small near objects, in planes passing through the vertical meridian